SHEAR AND COMPRESSIVE STRENGTH PARALLEL TO GRAIN OF MANGO (*Mangifera indica)*AT TWO MOISTURE REGIMES IN A HUMID ENVIRONMENT.

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Abstract
This study examined Compressive strength parallel to grain (CS//G) and shear strength(SS) of *Mangifera indica*woods in their axial directions at Rivers State University of Science and Technology, Nkpolu-Oroworukwo, Port Harcourt, Nigeria. Specimens were taken from three trees selected randomlyand prepared in accordance with British standard(BS 373) and American Society of Testing and Materials andanalysed at the Forestry Research Institute of Nigeria(FRIN). Samples were collected from the top, middle and base of merchantable height.Oven dry method (12% MC) and green state (90%MC). The result indicated that there was no significant difference (P >0.05) between CS//G in the wet and dry bases along axial direction but there was significant difference (P<0.05) between CS//grain along the vertical lengths.The CS//G was highest at the base (21.32 Nmm^2) followed by the middle (19.09 Nmm^2) and least at the top (13.34 Nmm^2) on wet basis while on dry basis the same trend followed; base (21.74 Nmm^2), middle (21.65Nmm^2),top (14.60 Nmm^2). There was no significant difference (P>0.05) between SS in their various moisture regimes along axial heights.The result showed that at the wet basis, the base had the highest with 8.52 Nmm^2 followed by the middle with 7.98 Nmm^2 and lowest at the top with 7.89 Nmm^{2}whereas on db, middle recorded the highest with 8.96 Nmm^2 followed by the base with 8.93 Nmm^2 and least at the top with 7.55 Nmm^2 .Result revealedthat *Mangifera indica* isstronger in their dry state compared to their green state both in compression and in shearalong axial variation.

Keywords:*Mangifera indica,Compressive strength, grain, shear strength*

Introduction

From time immemorial wood has remained one of the natural resources which is so important to man and found virtually in every part of his environment (Eaton and Hale, 1993). Woods are used for so many purposes because of its unique structural material ranging from pulp and paper making (PPM), building, construction, medicine, acoustics etc. In fact its usefulness cannot be overemphasised. Today the United State of America (USA) uses almost half of its woods harvested from the forest as building materials for construction purposes (Falk, 2010). This is evident in the fact that the growing demand for wood and its products has increased tremendously at 1-2 % per year with the world production of wood as at 1990 recording about 16,000 million cubic meters (FAO,1993). In Nigeria,our homes serves as relaxation niche for every family member and there is virtually no home that does not have a touch of wood for decoration-which gives it (i.e. home) that elegance, panache, warmth and ambience Labode (2013) reported that over 74% of the people in Lagos and Ogun state, South-west, Nigeria are interested in the use of wood and its associates for their interior decoration in their homes. Woods are renewable resources unlike other materials. With proper managementof the resources they can be maintained and utilised indefinitely (Falk, 2010).

One of such wood is the*Mangifera indica*, it has been known for only it food purposes and medical use, but little assessment has been carried out on its usefulness of it mechanical properties.

The wood tree *Mangifera indica* otherwise known as Mangois a juicy fruit tree species in the family of Anacardiaceaeand genus *Mangifera*. They are deep rooted evergreen trees that grows in tropical climate and attains a height of 15-30m (50-100 feet) and cultivated trees are usually 3-10m(10-33 ft) high when mature (Bally, 2006).

Materials and Method

Study Area

The study was carried out inRivers State University of Science and Technology, Nkpolu-Oroworukwo, Port Harcourt, River state Nigeria located on longitude 6^{o}44'N and 7^{o}33N and latitude 4^{o}38'E and 5^{o}5'E in Eastern part of Niger Delta with annual rainfall of about 2500mm. seasonal variation is wet and dry season. Three mature standing trees of *Mangifera indica* were randomly selected and felled.

Preparation of Sample

Tree samples were collected from the Top, Middle, and Base of merchantable height (Mitchell and Dane, 1997). Specimens from the different positions were trimmed to 20x20x300mm in accordance to British Standard(BS) 373(1957) for Modulus of Rupture, Modulus of elasticity and Impact Strength.

Test samples were taken to the Forestry Research Institute of Nigeria (FRIN), Ibadan for assessment. The wood specimens were oven dried at 105^{0}C and conditioned to have a stabilised moisture content of 12% for comparison with the moist wood at 90% MC.

Determination of Compressive strength parallel to grain(CS//G)

The compressive strength parallel to grain was determined using the test sample (British Standard, 373, 1957). A tensometer with a special jig was used, to ensure uniform distribution of load over the cross section to prevent buckling. Loads was applied at rate of 0.01mm/sec until failure occurs and recorded accordingly. The Maximum Compressive strength parallel to grain calculated thus;

$$CS = \frac{Pmax}{ab}$$

Where;

CS = Compressive Strength (N/mm^2)
Pmax = Maximum Load (N)
a =Length of Sample (mm)
b =Breath of Sample (mm)

Determination of Shear strength

The shear test was determined in accordance with ASTM (2009) whereby the set up was consisted of a test piece that failed along only one zone of the shear. Calculated thus;

$$\tau = \frac{F}{A}$$

Where;

τ =Shear Strength
F = Applied Force
A = Cross sectional area of wood with area parallel to the applied force.

Experimental Design and Data Analysis

Completely randomised design with three treatments replicated thrice and a descriptive statistics and a one-way analysis of variance (ANOVA) were used to analyse the data.

Results

The Compressive strength of the sampled wood stands showed that there was no significance difference (P>0.005) at their different moisture regimes (wet and dry) and between interactions of the woods. Contrarily, at the axial heights, the results indicated that there was a significant difference (P<0.05) between the woods (Appendix1). However, Table 1.Shows that the Compressive strength along the axial lengths on the wet state indicates that Tree 2 had the highest CS of 19.66 Nmm^2 (18.07-21-19 Nmm^2) followed by Tree 3 with 17.29 Nmm^2 (12.03-21.32 Nmm^2) and least with Tree 1 having 16.79 Nmm^2 (9.93-21.45 Nmm^2). Similarly, on dry basis, Tree 2 is highest in CS with 20.01 Nmm^2 (14.19-23.93 Nmm^2) followed by Tree 3, 18.95 Nmm^2 (14.31-21.32 Nmm^2) and least was Tree 1 with 18.91Nmm^2 (15.32-21.44 Nmm^2) (Table 1).

Table 1: Compressive Strength Parallel to Grain (C//G) in Axial direction on Wet and Dry (@ 12 %MC) Bases

Tree Number	Top (Nmm^2)	Middle(Nmm^2)	Base(Nmm^2)	Average(Nmm^2)
Dry				
Tree 1	9.93	19.00	21.45	16.79
Tree 2	18.07	19.73	21.19	19.66
Tree3	12.03	18.54	21.32	17.29
Average	13.34	19.09	21.32	17.91
Wet				
Tree 1	15.32	21.81	19.98	18.91
Tree 2	14.19	21.93	23.93	20.01
Tree3	14.31	21.22	21.32	18.95
Average	14.60	21.65	21.74	19.29

Shear Strength of *Mangifera indica*

Shear Strength values as seen in Appendix 2 showed that there was no significant difference (P>0.05) in their various moisture regimes, along axial heights and parameter interactions between the stands sampled. Howbeit, the results indicated that Tree 2 had the highest SS on the wet basis along axial lengths- 8.51 Nmm^2(8.00-9.04 Nmm^2) followed by Tree 3 with 8.21 Nmm^2(8.10-8.32 Nmm^2) and least SS Tree 1 with 7.67 Nmm^2(6.98-8.21 Nmm^2).On dry basis ,the linear trend still followed with Tree 2 recording the highest with 9.14 Nmm^2(7.59-10.05 Nmm^2) followed by Tree 3, 8.18 Nmm^2(7.23-9.00 Nmm^2) and least recorded in Tree 1 with 8.12 Nmm^2(7.84-8.70 Nmm^2) (Figure 1).

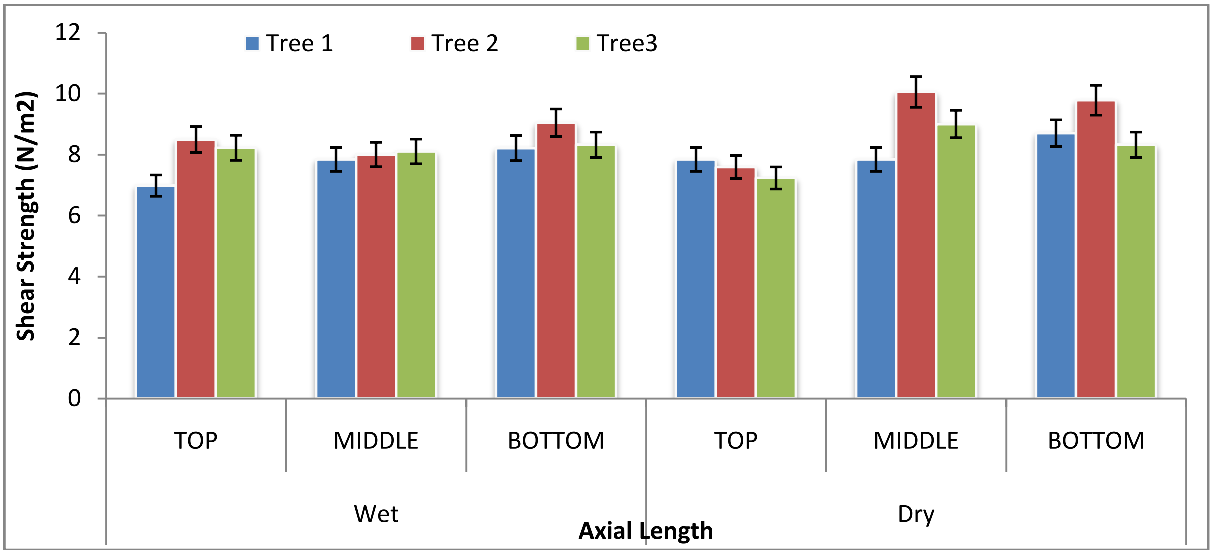

Figure 1: Shear strength of mango trees along vertical length

Discussion

Compressive Strength Parallel to Grain (C//G)

The quality of the strength properties of wood particularly compressive strength depends on the moisture content under normal climate conditions because moisture gradients in wood helps to enhance the risk of cracking and can have no effect on load carrying capacity (Alpo, 2001). The finding of this report goes contrary to this assertion –there was no effect of moisture in their wet and dry basis of the compressive strength. This could be attributed to the loss of free water down to the FSP in the species has no effect on the strength of the wood. Conversely, at their axial lengths there was an increase from the top to the bottom and this disagrees with the findings of Nwiisuator&Emerhi(2014), Aguda*et al* (2012) and Adedipe (2004) on *Allanblackia floribunda*,*Chyrstophyllumalbidum* and *Gmelinaarborea*, respectively. This variation trend could be due to variability in wood properties with special reference to morphological characteristics and natural variation in wood (Adejoba, 2008) and density, dynamic interstitial micro-fibril and quality of individual wood cells (David, 2013).

Shear strength

Shear strength is the ability to resist internal slipping of one part upon another along the grain (Yee, 2013). There was no variation between the shear strength properties and different moisture regimes. Hence, it is assumed that moisture does not have any major part to play in the three *Mangifera indica* species in relation to their shear strength. At their axial length, there was an increase from the top to the base with slight variation at the middle but not significant. This is evident to the fact that with high density and specific gravity of the wood it can be used for construction purposes because of its strength properties (Green *et al.*,2003;Ochnogor and Onilude, 1985).

CONCLUSION

The non effect of moisture to the wood, *Mangiferaindica* indicates that the wood is strong and has exhibited high strength properties in both compression and shear. Hence, the wood of the species with there outstanding properties and quality attributes will be useable in services and where maximum pressure is needed. It is pertinent that other wood strength properties be carried to unravel its properties holistically.

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Appendices

Appendix 1: ANOVA of CS//Grain of sampled woods

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (wet & dry)	8.514689	1	8.514689	2.241897	0.16015	4.747225
Columns (axial length)	197.4558	2	98.72791	25.99482	4.35E-05	3.885294
Interaction	3.078544	2	1.539272	0.405287	0.675579	3.885294
Within	45.5758	12	3.797983			
Total	254.6248	17				

Accept Ho since $F_{cal} < F_{crit}$: there is no significant difference (P>0.05) between CS//grain of wet and dry sampled wood.
Reject Ho since $F_{cal} > F_{crit}$: there is significant difference (P<0.05) between CS//grain along the vertical lengths of sampled woods
Accept Ho since $F_{cal} < F_{crit}$: there is no significant difference (P>0.05) between interaction of CS//grain parameters of sampled woods.

Appendix 2: ANOVA of SS of sampled woods

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	0.55125	1	0.55125	1.198949	0.295023	4.747225
Columns	3.260133	2	1.630067	3.545336	0.061682	3.885294
Interaction	1.328133	2	0.664067	1.444321	0.27413	3.885294
Within	5.517333	12	0.459778			
Total	10.65685	17				

Accept Ho since $F_{cal}<F_{crit}$: there is no significant difference (P>0.05) between SS of wet and dry sampled wood.
Accept Ho since $F_{cal}<F_{crit}$: there is no significant difference (P>0.05) between SS of along the axial length of sampled wood.
Accept Ho since $F_{cal}<F_{crit}$: there is no significant difference (P>0.05) between interaction of SS of parameters of sampled woods.